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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

Bureau of Standards
SEP 20 1937

PROGRAM

FOR THE

NORTH CAROLINA MEETING

FEBRUARY 19–20, 1937

AT

CHAPEL HILL AND DURHAM

JOINT MEETING

WITH THE

SOUTHEASTERN SECTION OF THE AMERICAN PHYSICAL SOCIETY

AND THE

AMERICAN ASSOCIATION OF PHYSICS TEACHERS

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

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The President, Vice President, Secretary, Treasurer, Managing Editor, the three Past Presidents most recently retired from office, eight elected members and all Past Presidents first elected to the office of President prior to December 1932 constitute the Council which shall have general charge of the affairs of the Society.

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BULLETIN

of the

AMERICAN PHYSICAL SOCIETY

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FEBRUARY 2, 1937 Vol. 12, No. 1, Part 1

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

NORTH CAROLINA MEETING, FEBRUARY 19–20, 1937

JOINT MEETING WITH THE SOUTHEASTERN SECTION OF THE AMERICAN PHYSICAL SOCIETY AND THE AMERICAN ASSOCIATION OF PHYSICS TEACHERS

THE 212th regular meeting of the American Physical Society will be held on Friday and Saturday, February 19 and 20, 1937, at Chapel Hill and Durham, North Carolina, in affiliation with the Southeastern Section of the American Physical Society and the American Association of Physics Teachers.

There will be sessions for the reading of contributed papers on Friday afternoon at Duke University and on Saturday afternoon at the University of North Carolina. The schedule of these papers is given below.

Symposium on Nuclear Physics. On Friday morning at ten o'clock in Room 116, Chemistry Building, at Duke University there will be held a symposium of invited papers on *Nuclear Physics*. The speakers will be Professor Niels Bohr of The University of Copenhagen and Professor Hans A. Bethe of Cornell University.

Symposium on Some Problems of Physics Teaching. On Saturday morning at nine-forty-five o'clock in Room 206, Venable Hall, at the University of North Carolina there will be held a symposium on *Some Problems of Physics Teaching*. The speakers will be Dean L. L. Hendren of the University of Georgia, Professor Thomas D. Cope of the University of Pennsylvania, and Professor G. P. Harnwell of Princeton University. This program is sponsored by the American Association of Physics Teachers.

Symposium on Applied Physics. On Saturday morning at nine o'clock in Room 206, Phillips Hall, at the University of North Carolina there will be held a symposium on *Applied Physics*. The speakers will be Dr. Wanda K. Farr of the Boyce-Thompson Institute for Plant Research, Dr. A. C. Walker of the Bell Telephone Laboratories, Inc., Mr. J. P. Elting of the Kendall Mills, and Professor A. C. Hardy of the Massachusetts Institute of Technology.

Sigma Pi Sigma. On Friday afternoon, February 19, at two o'clock the Beta Chapter of Sigma Pi Sigma at Duke University will hold an open meeting at which the topic *The Physicists' Training for Industry* will be discussed. All students of physics are invited.

The Society of Sigma Xi. On Thursday evening, February 18, at eight o'clock in Room 206, Phillips Hall, at the University of North Carolina, the Society of Sigma Xi will hold an open meeting at which there will be an address by Professor John R. Dunning of Columbia University on *The Neutron and Atomic Transmutations*.

Dinner. On Friday evening at seven o'clock there will be a joint dinner for the members of the societies and their friends in the University Union Building of Duke University. President Randall will preside. Addresses of welcome will be given by University officials followed by an address by Dean George B. Pegram of Columbia University. The price of the dinner will be $1.00 per plate. Tickets will be on sale at the Durham hotels on Thursday evening and at the

registration desk on Friday. Reservations should be made not later than twelve o'clock Friday.

Exhibits. There will be exhibits of books and apparatus in the lobby of the Duke Chemistry Building on Friday and in Room 204, Phillips Hall, on Saturday.

Business Meeting of the Southeastern Section. A business meeting of the Southeastern Section will be held on Friday, February 19 at one-fifteen P.M. in the Duke Physics Building.

Luncheon. Duke University will give a complimentary luncheon on Friday, February 19 at one-fifteen to two-fifteen.

Luncheon may be had on Saturday at either the Carolina Inn Dining Room (50¢ to 75¢) or Carolina Inn Cafeteria (about 35¢) or Swain Hall (about 25¢).

Chapel Hill. On Saturday afternoon from one to two o'clock the physics laboratories will be open to visitors.

A reception will be held at the Graham Memorial Building at four-thirty P.M.

Entertainment Program for Visiting Ladies. A tour of the tobacco auction markets and cigarette factories is scheduled for Friday morning at ten o'clock and also a tour of the Woman's College. A complimentary luncheon will be given by Duke University at one-fifteen P.M. A tour of Duke University ending with a carillon and organ recital in the University Chapel has been arranged for Friday afternoon from four-thirty to five-thirty o'clock.

A visual instruction demonstration will be held in Room 114, Physics Building.

On Saturday morning at Chapel Hill there will be a bridge at eleven o'clock at the Carolina Inn followed by a complimentary luncheon at one P.M. A reception will be held at the Graham Memorial Building at four-thirty.

Transportation. Durham is on the Southern Railway. A sleeping car runs direct from Washington (10:45 P.M.) to Durham (7:55 A.M.), via Greensboro. This train from Washington to Durham, which has a sleeping car shunted off without change at Greensboro, N. C., arrives at Greensboro at 5:45 A.M. Any passenger on the train but not on that particular sleeping car must get off the train at Greensboro at 5:45 A.M. He can leave Greensboro for Durham at either 6:15 A.M. or 11:30 A.M. There is no train between.

One may also use the Seaboard Air Line to Raleigh (New York 10:30 A.M., arrive Raleigh 9:30 P.M.) and go 26 miles by bus to Durham. Automobiles from the north follow U. S. Route 1 to Henderson, N. C., U. S. 158 to Oxford, and U. S. 15 to Durham. Avoid the belt line route around Richmond; go through the city.

Chapel Hill is twelve miles south of Durham and is reached by buses running at frequent intervals. Special buses (round trip fare 50¢) will leave the Washington Duke Hotel for Chapel Hill at 9:00 A.M. Saturday. Returning, these buses will leave the Graham Memorial Building at 5:30 P.M. and 6:15 P.M.

Regular buses from Durham to Chapel Hill run at: 7:45 A.M., 9:00 A.M., 11:00 A.M., 12:30 P.M., 2:00 P.M., 5:00 P.M., 6:30 P.M., 8:45 P.M., 10:00 P.M., and 11:30 P.M. From Chapel Hill to Durham: 8:15 A.M., 9:40 A.M., 11:35 A.M., 12:55 P.M., 3:30 P.M., 5:30 P.M., 7:15 P.M., 9:15 P.M., and 10:40 P.M.

Taxicab from Durham hotels to Duke campus, 25 cents; also frequent bus service; taxicab from Durham Railway Station to Duke campus, 25 cents; taxi fare anywhere in Chapel Hill is 25 cents (Phone No. 4811).

Hotel Headquarters and Accommodations. (Prices are given per *room*. For example, if two people occupy room with two single beds at the Malbourne, charge is $1.25 per person.)

Washington Duke Hotel. Durham, is designated as headquarters. All rooms have private baths. Single rooms are from $2.50, double rooms from $3.50, twin-bed rooms from $4.50.

The Malbourne Hotel, Durham—rooms without bath: single bed, $1.75; one double bed, $2.50; two single beds, $3.00; two double beds, $5.00. Rooms with bath: single bed, $2.25, $2.50; one double bed, $3.50, $4.00; two single beds, $4.00, $4.50; two double beds, $6.00, $8.00.

Hotel Sir Walter, Raleigh—single room with bath, radio and circulating ice water in every room: $2.50 to $5.00; double rooms, $3.50 to $7.00; twin beds begin at $5.00.

Hotel Carolina, Raleigh—single rooms $2.50 and $3.00; double rooms (double bed) $4.00 and $4.50; double rooms (twin beds) $4.50 to $6.00. All rooms with bath, radio and electric fans.

The Carolina Inn, Chapel Hill—rooms with bath: single, $2.50 and $3.00, double rooms (double bed) $4.00, double rooms (twin beds) $5.00.

Registration. There will be registration desks at the Washington Duke Hotel, Malbourne Hotel, and Carolina Inn, Thursday evening, February 18; at Chemistry Building lobby, Friday, and at Phillips Hall, Physics Department Office, Saturday.

Members are urgently requested to register and to give the names of ladies accompanying them.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

On December 28, 1936 the Society voted that:

> No papers may be accepted for presentation at any meeting of the Society subsequent to the closing date stated in the printed call for that meeting.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.)

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Publications Manager, The American Institute of Physics Incorporated, 175 Fifth Avenue, New York, N. Y.

Other meetings for the current season are as follows:

213. April 29–May 1, 1937. Washington, D. C.
214. June 21–25, 1937. Denver, Colorado. Pacific Coast Section.
215. June 22–23, 1937. Madison, Wisconsin.
216. November 26–27, 1937. Chicago, Illinois.
217. Pacific Coast Meeting, December, 1937.
218. Annual Meeting. December 27, 1937–January 1, 1938. Indianapolis, Indiana.

W. L. Severinghaus, *Secretary*
Columbia University, New York, N. Y.

February 2, 1937.

ADVANCE REGISTRATION CARD

American Physical Society

North Carolina Meeting—February 19–20, 1937

Please return this card at once if you expect to attend the meeting.

Name.....
Last name First name Other initials

Names of persons in your party who are not members of A. P. S., A. A. P. T. or Southeastern Section of A. P. S.

....

Hotel.....

Are you coming by automobile or train?.....Time of arrival.....

Please reserve.....seats in buses to and from Chapel Hill, Feb. 20. Round trip 50¢.

Please reserve.....tickets for dinner @ $1.00.

Please reserve.....places, complimentary luncheon, Feb. 19, 1:15 P.M.

Please reserve.....places, reception, Feb. 20, 4:30 P.M.

Return this card to:

Department of Physics, Duke University, Durham, North Carolina.

CALENDAR

Thursday evening, February 18—Chapel Hill

8:00 o'clock: Phillips Hall: Room 206: Society of Sigma Xi open meeting. Address by Professor John R. Dunning.

Friday morning, February 19—Durham

10:00 o'clock: Chemistry Building: Room 116: Symposium on *Nuclear Physics*. Addresses by Professor Niels Bohr and Professor Hans A. Bethe. See page 7.

10:00 o'clock: Tour of tobacco auction markets and cigarette factories. Tour of Woman's College.

Friday afternoon, February 19—Durham

1:15 o'clock: University Union: Complimentary luncheon.

1:15 o'clock: Physics Building: Business meeting of the Southeastern Section.

2:00 o'clock: Physics Building: Sigma Pi Sigma open meeting to discuss *The Physicists' Training for Industry*.

2:15 o'clock: Biology Building: Room 113: Papers No. 1–9. See pages 7–9.

2:15 o'clock: Chemistry Building: Room 116: Papers No. 10–20. See pages 9–11.

4:00 o'clock: Meeting of the Council of the A.P.S.

4:30 o'clock: Tour of Duke University with a carillon and organ recital in University Chapel.

Friday evening, February 19—Durham

7:00 o'clock: University Union: Dinner.

Saturday morning, February 20—Chapel Hill

9:45 o'clock: Venable Hall: Room 206: Symposium on *Some Problems of Physics Teaching*. Addresses by Dean L. L. Hendren, Professor Thomas D. Cope, and Professor G. P. Harnwell. See page 11.

9:45 o'clock: Phillips Hall: Room 206: Symposium on *Applied Physics*. Addresses by Dr. Wanda K. Farr, Dr. A. C. Walker, Mr. J. P. Elting, and Professor A. C. Hardy. See page 12.

11:00 o'clock: Carolina Inn: Bridge.

Saturday afternoon, February 20—Chapel Hill

1:00 o'clock: Carolina Inn: Complimentary luncheon for women.

1:00 o'clock: Physics Laboratories open to visitors.

2:00 o'clock: Phillips Hall: Room 206: Papers No. 21–33. See pages 12–14.

2:00 o'clock: Venable Hall: Room 206: Papers No. 34–46. See pages 14–16.

4:30 o'clock: Graham Memorial Building: Reception.

PROGRAM

FRIDAY MORNING AT 10:00 O'CLOCK AT DURHAM

Chemistry Building, Room 116

SYMPOSIUM ON NUCLEAR PHYSICS

1. PROFESSOR NIELS BOHR, *University of Copenhagen*. Title to be announced.
2. **Nuclear Reactions and Angular Momentum.** PROFESSOR HANS A. BETHE, *Cornell University*.

FRIDAY AFTERNOON AT 2:15 O'CLOCK AT DURHAM

Biology Building, Room 113

1. Calculations on Beta-Ray Spectra. W. G. POLLARD, *The University of Tennessee.*—Calculations have been made on beta-ray spectra using $\psi^*\varphi$, $\psi^*\vec{\alpha}\varphi$ for the Fermi interaction and $\psi^*\beta\partial\varphi/\partial t$, $C\psi^*\beta$ grad φ for the Konopinski-Uhlenbeck form. Special features of these calculations are: (1) The "vector" parts of the interaction are included and all matrix elements evaluated by assuming the heavy particle wave functions to be solutions of Dirac's equation in a square hole. (2) The depth of the hole is calculated for heavy elements by means of Van Vleck's potential in the form

$$U_\nu = 2(1-\tfrac{1}{2}g)\int_0^{p_\pi} \vec{dp}\, a(\vec{p}_\nu - \vec{p}) + 2(1-2g)\int_0^{p_\nu} \vec{dp}\, a(\vec{p}_\nu - \vec{p})$$

with $g=0.21$, the coefficients a adjusted to give the Fourier integral of Feenberg's and Knipp's interaction, and p_ν determined from the boundary conditions. (3) For the width of the hole Bethe's extended radius 13×10^{-13} cm was used. (4) The potentials U_ν or U_π were introduced into the wave equation so as to reduce the rest energy instead of the total energy as suggested by Furry. (5) The author's improved approximations to the electron wave functions were used. Kurie plots on Lyman's RaE spectrum have been made for $1p\rightarrow1s$, $2p\rightarrow1s$, $2s\rightarrow1p$, and $2p\rightarrow2s$ transitions for both F and KU interactions. The $KU: 1p\rightarrow1s$ plot is quite straight with only a slight lowering at the end. The results on light elements indicate that the use of the spectral distribution function for permissible transitions in making Kurie plots of forbidden spectra is justifiable within 2 or 3 percent. This is of course in agreement with experimental evidence.

2. Range of High Speed Electrons. ARTHUR BRAMLEY, *Swarthmore, Pa.*—Comparison of theoretical energy losses for cosmic-ray electrons indicates that losses arising from existence of Fermi interaction between light particles and nuclei are comparable with or even greater than losses predicted by the radiation theory.[1] Cross section for radiation is $\sigma=(6Z^2/137)(e^2/mc^2)^2\cdot\Phi/b$ where $5\leq\Phi\leq18$. Energy losses suffered by electrons of energy W as consequence of Fermi interaction may be divided thus: (1) Capture[2] of electron with creation of neutrino, $\sigma\sim10^{-30}(W/mc^2)^4$. (2) Collision with creation of two neutrinos, (a) $\sigma\sim10^{-46}(W/mc^2)^6$, for capture of electron in virtual level;[3] (b) $\sigma\sim10^{-31}(W/mc^2)^5$ through excitation of β-field of nucleus by electromagnetic field of colliding electron. Alternative process with comparable cross section dissipates energy as radiation rather than by neutrinos. These cross sections are valid for energies $\sim137\ mc^2$, where Fermi constant g has maximum.[4] Cross sections become negligible for electronic energies $\gg137\ mc^2$. For energies $<137\ mc^2$, only process (2b) retains large cross section. Since these processes favor large energy losses, comparison of experimental large losses[5] with predicted losses would establish the nature of Fermi's g-factor for high speed electrons.

[1] Bramley, Abs. 67, Atlantic City Meeting.
[2] Bethe and Bacher, Rev. Mod. Phys. **8**, 2 (1936).
[3] Bronstein, Zeits. d. Sowjetunion **9**, 537 (1936).
[4] v. Weizsacker, Zeits. f. Physik **102**, 572 (1936).
[5] Anderson and Neddermeyer, Phys. Rev. **50**, 263 (1936); Klarmann and Bothe, Zeits. f. Physik **101**, 489 (1936).

3. Stable States of Two Deuterons. HERMAN PARKER, *University of North Carolina.*—Previous studies of the binding energies of the light nuclei have been made, using a simple variational wave function of an exponential form, containing one or more parameters. A different type of wave function is suggested by the point of view which regards the alpha-particle as composed of two deuterons; on this basis we should start out with a wave function made up of the product of the internal wave functions of the two deuterons and a function U depending upon their separation. Thus

$$\Psi = U((1+3)/2-(2+4)/2)S(1,3;2,4)\varphi(3-1)\varphi(4-2) - U((1+4)/2-(2+3)/2)S(1,4;2,3)\varphi(4-1)\varphi(3-2), \quad (1)$$

where
$$U(x)=U(-x), \quad (2a)$$

$$S=6^{-\frac{1}{2}}\{2^{-\frac{1}{2}}[\alpha(1)\beta(3)+\alpha(3)\beta(1)]2^{-\frac{1}{2}}[\alpha(2)\beta(4)+\alpha(4)\beta(2)] - \alpha(1)\alpha(3)\beta(2)\beta(4)-\alpha(2)\alpha(4)\beta(1)\beta(3)\} \quad (2b)$$

and
$$\varphi(3-1)=C_\lambda \exp[-\lambda(3-1)^2] \quad (2c)$$

has been adopted as such a tried function, where the function of separation U gives effectively an infinite number of parameters to be adjusted to give the best wave

function. (1) is capable, to a certain approximation, of describing the system, not only in the ground state, but in the other discrete and continuous states as well. A differential-integral equation (derived by Dr. J. A. Wheeler) determines U. λ and the strength of the like and unlike particle forces were fixed by applying the usual variation procedure to fit the binding energies of ^{2}H and ^{3}H using the wave functions

$$\phi_{^2\mathrm{H}}=\alpha(1)\alpha(3)C_\lambda \exp[-\lambda(3-1)^2],$$
$$\phi_{^3\mathrm{H}}=2^{-\frac{1}{2}}\alpha(2)[\alpha(3)\beta(4)-\alpha(4)\beta(3)]C_{\mu\nu}\exp[-\mu\{(2-3)^2+(2-4)^2\}-\nu(3-4)^2].$$

U has been calculated for the ground state of the alpha-particle and the corresponding binding energy is compared with what one gets using the two-parameter function employed by Feenberg. Application of the same treatment to alpha-particle levels having spin $S=2$ (deuterons with parallel spin) gives no stable levels. Further investigations are planned, taking into account the improved description of the four-particle system using a superposition of the wave functions representing $^2\mathrm{H}+^2\mathrm{H}$, $^3\mathrm{H}+^1\mathrm{H}$, and $^3\mathrm{H}_e+^1n$.

4. Photoelectric Cross Section of the Deuteron. KATHARINE WAY AND JOHN A. WHEELER, *University of North Carolina.*—Several writers have pointed out that for Majorana forces the area under the photoelectric cross section curve $\int\sigma(\nu)d(h\nu)$ is not equal to $\pi e^2h/2Mc$ as it is for ordinary forces. A general formula for this deviation from the f-sum rule is derived and it is shown that for three special types of exchange forces

$$\int\sigma(\nu)d(h\nu)\geqq(\pi e^2h/2Mc)(1+a\alpha),$$

where a is the range of the interaction and α is defined by $\hbar^2\alpha^2/M=\epsilon$, the binding energy of the deuteron. Photoelectric cross-section curves for three different types of neutron-proton interactions are compared to see if experimental determination of the cross section for any value of $h\nu$ would furnish a criterion for deciding in favor of one of them. The three different types are (1) square hole Majorana, (2) bell-shaped Majorana, $V=V_0e^{-r^2/a^2}$, and (3) a velocity dependent interaction defined by $J_0=-(2B/a)e^{-(r+\rho)/a}$. The ranges and depths of the interactions chosen are those which have been shown to be best for accounting for the binding energies of H^2, H^3, and He^4. It is found that the cross-section curves for (2) and (3) are very similar but that they differ considerably from (1). The addition of a short depth, long range repulsive force to the velocity dependent interaction is shown to decrease the cross section for this type of interaction considerably.

5. Resonating Group Structure in the Nucleus. JOHN A. WHEELER, *University of North Carolina.*—By regarding the neutrons and protons in a given nucleus, ^{7}Li for example, as resonating between different possible configurations, such as ^{4}He(normal)$+^3$H(normal), ^{5}He(excited) $+^2$H(normal), etc., one obtains a description of nuclear structure in which by far the largest part of the energy of the compound nucleus is already accounted for by the internal binding of the separate groups. Use from the beginning of this saturation property of nuclear binding gives an improved treatment of nuclear collisions and transmutations. In applying the method of "resonating group structure," the wave function is written as a sum of properly anti-symmetrized parts corresponding to the most important configurations, each part involving a different unknown function, F, of the inter-group separations. The condition that the F's shall give the best possible wave function of this form (in the sense of the variation principle) gives simultaneous integro-differential equations for the F's. With the help of a generalized Green's function these equations are transformed to integral equations. The condition that the Fredholm determinant of this set of equations shall vanish determines energy levels, scattering phase shifts, and transmutation probabilities. The method gives very satisfactory results when applied to the interaction between two alpha-particles, and is being employed in the treatment of other collision problems.

6. On the Structure of Light Nuclei. E. FEENBERG AND M. PHILLIPS,* *Institute for Advanced Study.*—Extensive calculations based on the approximation of single particle wave functions (the Hartree method) have been made for the nuclei between He^6 and O^{16} using the general symmetrical interaction operator[1]

$$V=\sum_{i<j}\{(1-g-g_1-g_2)P_{ij}+gP_{ij}Q_{ij}+g_11+g_2Q_{ij}\}J(r_{ij}). \quad (1)$$

The Coulomb interaction is treated as a small perturbation. Secular equations are avoided by the construction of space wave functions in the normal state configuration belonging to irreducible representations of the symmetric group. These functions yield an energy matrix which is diagonal in the ordinary and Majorana interaction energies. The contributions of the spin exchange and Coulomb operators to the energy terms are found by a first order perturbation calculation. Although the general symmetrical operator contains several parameters as yet undetermined, only those parameters which have been fixed by consideration of the two-, three- and four-particle problems are involved in the energy differences within the group of low lying terms belonging to the normal state configuration. These term differences are essentially identical with those recently computed[2] for unsymmetrical interaction operators of the saturation type. Results for mass defects, excitation energies, energy relations between isobars, spins and magnetic moments are on the whole very encouraging.

* Margaret E. Maltby Fellow of the A.A.U.W.
[1] G. Breit and E. Feenberg, Phys. Rev. **50**, 850 (1936).
[2] E. Feenberg and E. Wigner, Phys. Rev. **51**, 95 (1937).

7. Transitions Between States of Space Quantization in a Rotating Magnetic Field. I. I. RABI, *Columbia University.*—A calculation of the nonadiabatic transition which a system with angular momentum $J=\frac{1}{2}$ and magnetic moment $-g\mu_0J$ makes in a magnetic field H rotating with frequency ω about an axis inclined at an angle ϑ to the field gives for the transition probability

$$P_{(\frac{1}{2},\,-\frac{1}{2})}=\frac{\sin^2\vartheta\omega^2}{\nu^2+\omega^2-2\nu\omega\cos\vartheta}\sin^2\pi t(\nu^2+\omega^2-2\nu\omega\cos\vartheta)^{\frac{1}{2}},$$

where ν is the Larmor frequency $g\mu_0H/h$. The generalization for any value of J follows immediately from Majorana's formula. It is evident that the effect depends on the sign of

the magnetic moment of the system through the sign of ν. We thus have an absolute method of measuring the sign and magnitude of the magnetic moment of any system. Applications to the moment of the neutron, the rotational moment of molecules and the nuclear moment of atoms with no extra nuclear angular momentum will be discussed.

8. The Molecular Volumes and Lattice Forces of Liquid Normal- and Para-Hydrogen. R. B. SCOTT AND F. G. BRICKWEDDE, *National Bureau of Standards.*—The volumes between 14° and 20.4°K were measured with a quartz dilatometer, the mass of hydrogen being determined from the pressure of the gas in a calibrated flask whose temperature was measured. The results are represented by the equations:

$$V(n-H_2)\ \text{cm}^3\text{mol}^{-1} = 24.747 - 0.08005T + 0.012716T^2,$$
$$V(p-H_2)\ \text{cm}^3\text{mol}^{-1} = 24.902 - 0.0888T + 0.013104T^2.$$

At the normal boiling point of $n-H_2$(20.38°K), $V(n-H_2) = 28.397 \pm 0.010$ and $\Delta V(p-n) = 0.138 \pm 0.010$. The expansivity of $p-H_2$ is only slightly greater than that of $n-H_2$. For H_2, the nonrotating variety ($p-H_2$) has a larger energy and volume than the rotating variety ($o-H_2$). This is opposite to the direction of the difference observed for other substances whose molecules are oriented at low temperatures. The uncertainty principle shows that the nonrotating state of $p-H_2$ is fundamentally like that of free rotation in other substances. The difference between the lattice forces of condensed $p-H_2$ and $n-H_2$ arises from the difference in the average electron distribution of the molecules. The average angular distribution of the orientations of the axis of an H_2 molecule, which determines the average electron distribution, is given by the Legendre polynomials of the ψ-function for a rotator.

9. The Nuclear Separation of the Te_2 Molecule by Electron Diffraction. LOUIS R. MAXWELL AND V. M. MOSLEY, *Bureau of Chemistry and Soils, Washington, D. C.*—Electron diffraction photographs obtained from tellurium vapor show an interference pattern which can be explained by electron scattering from the diatomic tellurium molecule. Visual measurements were taken on the second, third, fourth and fifth interference maxima which are found to occur at $(1/\lambda)\sin\frac{1}{2}\theta = 0.422$, 0.618, 0.815 and 1.018 respectively. These values lead to a Te−Te separation of 2.59 ± 0.02A, where the variation given represents the average deviation. This distance is considerably less than the accepted band spectra value of 2.85A for the nuclear separation of the ground state of the Te_2 molecule.* Additional electron diffraction data have been obtained from I_2 giving an I−I distance of 2.66 ± 0.01 which is exactly equal to the band spectra value for the internuclear distance in the normal state of I_2.* Further agreement has already been obtained by various workers between electron diffraction and band spectra for the molecules Br_2 and Cl_2. On the basis of the above information we conclude that at least part of the rotational constants computed for Te_2 from band spectra data must be in error.

* See for instance *Report on Band Spectra of Diatomic Molecules* by W. Jevons.

FRIDAY AFTERNOON AT 2:15 O'CLOCK AT DURHAM

Chemistry Building, Room 116

SOUTHEASTERN SECTION OF THE AMERICAN PHYSICAL SOCIETY

Officers

Chairman, PROFESSOR D. S. ELLIOTT, *Tulane University*
Vice-Chairman, PROFESSOR W. L. KENNON, *University of Mississippi*
Secretary, PROFESSOR FRANCIS G. SLACK, *Vanderbilt University*
Treasurer, PROFESSOR W. S. NELMS, *Emory University*

10. Response of Synthetic Rubber to Temperature Changes. MILTON L. BRAUN, *Catawba College.*—From a sheet of DuPont synthetic rubber about 2 mm in thickness was cut a double hairpin shape band of approximately square cross section and about 7 cm in length. From the band, in a closed cabinet, was suspended a kilogram load which produced an immediate stretch of nearly 50 percent. The length of the band was observed at numerous intervals under various temperature sequences within an extreme range of 16 to 48°C, and over a duration of about ten months. The band showed a drift quite comparable to that in ordinary vulcanized rubber. Superimposed on this drift, the rate of change of length with temperature was found to be about −0.0215 cm per degree. This rate held consistently from the first through the tenth (present) month. A similar control band without load showed practically no change in length with temperature, and in this respect it differed from a slight positive rate ordinarily found for unloaded vulcanized bands. The present elongation is about 400 percent, nearly one-half of which is accounted for by the drift effect, the other half by a sudden rise in the drift curve probably due to a plastic give when the temperature one time reached the neighborhood of 48°.

11. Measurement of Permeability of Porous Media by a Radial Flow Method. O. T. KOPPIUS AND W. G. HOLTON,

University of Kentucky.—A theory and method is presented by which the permeability of a consolidated medium to gas and to liquid flow may be determined. The specimens used were diamond drill cores from oil sands. The fluid flow in the sample was radial, and the flow was confined entirely to the region of viscous flow where D'Arcy's law applies. The permeabilities of the sample were found to be different for gas flow from that for liquid flow, being 9.64 millidarcies for air and 4.00 millidarcies for furnace oil. This difference between the permeability of the sample for gas and liquid flow is at variance with the results obtained by other observers using a linear flow method and materials whose permeabilities for air were about 120 times as great. The question is raised as to whether the constant in D'Arcy's equation, $C=k/\mu$, is of such simple form when this equation is applied to materials having as small a permeability as the sample used here. No "plugging" action of the sample for liquid flow was observed.

12. A Spark Timer Actuated by Thermionic Tubes, C. T. RAZOR, *The Citadel.*—A strip of sensitized paper is clamped to a drum driven at constant speed by a synchronous motor. The paper is marked by a spark discharge from an electrode near the drum. The spark is produced by the action of a grid glow tube circuit which resets itself within a few milliseconds to produce another spark, without the use of mechanical relays or contacts. The spark discharge may be controlled by successive sound pulses through a microphone and amplifier. The time between any of a series of low frequency voltage pulses may be determined. Any mechanical action which can be made to close two electrical contacts in succession may be timed.

13. A Study of the Thyratron Inverter. MARVIN SLEDD AND J. B. PEEBLES, *Emory University.*—By the use of the operational calculus, considerable progress can be made in the effort to predict mathematically the behavior of the self-excited, parallel-type, single-phase inverter with static loads. The frequency can be calculated within 5 percent of the observed value, and a fair approximation of the wave shape of the output voltage can be obtained. Several parts of the inverter circuits often seen can be omitted, and the apparatus will continue to function. Perhaps the most interesting example of this statement is the fact that, by proper adjustment of the grid circuit, the separate commutating condenser can be dispensed with. And after this is done, the inverter will continue to deliver load to an output circuit consisting of inductance and resistance only. By a proper adjustment of the circuit, a sine wave of voltage can be obtained in the load in which no harmonic exceeds 3 percent of the fundamental.

14. Electrolytic Polarization with Alternating Current. SCHUYLER M. CHRISTIAN, *Agnes Scott College.*—A comprehensive investigation of this phenomenon is outlined, the resistance and capacitance of the electrodes being measured. The effects of the following factors have been studied: (1) frequency, (2) distance between electrodes, (3) current density, (4) temperature, (5) nature of solution, (6) nature of electrodes, (7) superimposed d.c., (8) superimposed a.c. Of these effects, the first is most definitely established: the resistance and capacitance vary inversely as the square root of the frequency, within the limits of experimental error. The best theory to account for the observed facts is based on the diffusion of ions from the electrodes; though incomplete, this is more satisfactory than the concept of a gaseous film surrounding the electrodes.

15. Measurements of the Verdet Constant of Crystalline Nickelous Sulphate. F. G. SLACK, R. T. LAGEMAN AND NEWTON UNDERWOOD, *Vanderbilt University.*—The Verdet constant of "Baker's Analyzed" nickelous sulphate crystals, $NiSO_4 \cdot 6H_2O$, has been measured for light passing normal to the natural cleavage plane of the crystal. The set up consists of a special drilled core Leybold electromagnet which fits between the polarizer and analyzer of a Lippich half-shade polarimeter. The sample is oriented, by means of a goniometer head, in the narrow gap between the pole pieces. Light from an automobile head light passing through a B. & L. monochromator serves as a source. Measurements between 4500A and 6000A show the Verdet constant to vary inversely as the square of the wave-length. Temperature measurements over the range $-10°C$ to $30°C$ show a temperature variation in the Verdet constant proportional inversely to the absolute temperature.

16. An Infrared Study of Alcohol-Acetate Mixtures. E. S. BARR, *Tulane University.*—The infrared spectra of methyl and ethyl alcohols and of their acetates, as well as mixtures of these, have been obtained in the region from 4μ to 8μ. Anhydrous materials were used to prevent confusion due to hydrolysis and hydration effects. The ethyl alcohol-methyl acetate and methyl alcohol-ethyl acetate mixtures were refluxed for thirty-six hours and left undisturbed for six months, to facilitate any possible exchange reactions. The spectrum of the methyl alcohol-ethyl acetate mixture showed no indication of either ethyl alcohol or methyl acetate. Likewise, the ethyl alcohol-methyl acetate spectrum showed only bands due to its original constituents. This is taken as an indication that no exchange reaction takes place in the absence of water. Furthermore, the absence of new bands or marked modifications of the combined spectra of the mixtures indicates that there is very little, if any, interaction. As a check on this supposition, calculations based upon the assumption of no interaction were used to plot curves for a mechanical mixture of the substances. These curves were found to be in excellent agreement with the observed curves.

17. The Infrared Spectra of Binary Mixtures of Certain Organic Liquids. DUDLEY WILLIAMS AND WALTER GORDY, *University of Florida and Baylor College.*—The spectra of methyl alcohol-ethyl formate and methyl alcohol-ethyl acetate mixtures were studied in the region between 2μ and 10μ. The presence of the esters was found to shift the OH band of methyl alcohol to shorter wave-lengths and to increase its intensity. On the other hand the CO band of the esters was shifted to longer wave-lengths by the alcohol. These results are interpreted as arising from the effects of association between the components of the mixture. The

possibility of a type of association involving the formation of proton bonds is discussed.

18. Infrared Absorption of Strong and Weak Acid Solutions, E. K. PLYLER, *University of North Carolina at Chapel Hill.*—A study has been made of infrared absorption spectra of aqueous solutions of HCl and HBr. The solution strengths were varied from 1 N to 8 N, and in the region of 5.4μ intense absorption was observed. As this absorption band is not due to water or the acid molecule, it was concluded that it is produced by the hydrated ion or molecule. Solutions of propionic and acetic acids were also studied and they showed strong absorption in the region of 5.75μ, which is also due to hydration. Several other acids have been studied and it is found in all cases that strong acids in solution produce a band at 5.4μ, and weak acids in solution produce a band at 5.75μ. This difference in the position of the hydration band is explained by attributing the absorption at 5.4μ to the hydrated ion, and the absorption at 5.75μ to the hydrated acid molecule.

19. The Infrared Absorption of Various Solutions of Acetic Acid. WALTER GORDY, *Mary Hardin-Baylor College and the University of North Carolina.*—The characteristic vibrational band associated with the C=O group of acetic acid has been studied as a function of concentration of acetic acid in benzene, in carbon tetrachloride, and in iso-propyl ether. The effects of benzene and carbon tetrachloride on the band were approximately the same. In both solvents the band became sharper, its intensity was increased, and its center was shifted to the longer wave-lengths. For concentrations of acetic acid as low as 6 per-cent the shift amounted to 0.15μ. Although in iso-propyl ether solution there was a measurable shift of the band to the longer wave-lengths, the shift was small compared to that observed for benzene and carbon tetrachloride solutions. It is suggested that the changes in the C=O acetic acid band are likely due to variations in the polymerization of the acetic acid as the concentration is varied. However, the position of the band does not approach that for the vapor state in any of these solvents. Ethyl acetate was also studied in benzene and in iso-propyl ether; no variations could be detected in the C=O band.

20. Spirals in Paraffin Crystals. CHARLES M. HECK, *North Carolina State College of Agriculture and Engineering.*—Some two hundred spirals formed in tabular paraffin crystals have been photographed. They have the following characteristics: (a) the convolutions follow accurately the pinacoidal diamond shape of the exterior of a perfect crystal; (b) they always have their axes parallel to the axes of the crystal; (c) though generally concentric with the crystal, they may appear in any part of it; (d) more than one spiral may be present in a single crystal: generally this occurs when internal lines and external configuration indicate a form of twining. Generally the directions of the windings in two contiguous spirals in the same crystal are opposite; (e) spirals are more often perfect when the heavier fractions of Pennsylvania paraffin are crystallized from a liquid composed of the lighter members of the paraffin series; (f) spirals tend to lose their angles and become circular as the degree of crystallinity of the paraffin is diminished or the solution from which it is crystallized poisons them.

SATURDAY MORNING AT 9:45 O'CLOCK AT CHAPEL HILL

Venable Hall, Room 206

AMERICAN ASSOCIATION OF PHYSICS TEACHERS

Officers

President, PROFESSOR F. K. RICHTMYER, *Cornell University*
Vice President, PROFESSOR HARVEY B. LEMON, *University of Chicago*
Secretary, PROFESSOR THOMAS D. COPE, *University of Pennsylvania*
Treasurer, DR. PAUL E. KLOPSTEG, *Central Scientific Company, Chicago, Ill.*

SYMPOSIUM ON SOME PROBLEMS OF PHYSICS TEACHING

1. **Some Aspects of Physics Teaching in the South.** DEAN L. L. HENDREN, *University of Georgia.*
2. **What College Physics Expects of Pre-College Education.** PROFESSOR THOMAS D. COPE, *University of Pennsylvania.*
3. **Graduate Training for a Career in Physics.** PROFESSOR G. P. HARNWELL, *Princeton University.*

Saturday Morning at 9:45 o'clock at Chapel Hill

Phillips Hall, Room 206

SYMPOSIUM ON APPLIED PHYSICS

1. **The Structure of the Cotton Fiber.** Dr. Wanda K. Farr, *Boyce-Thompson Institute for Plant Research, Yonkers, N. Y.*
2. **Moisture in Textiles.** Dr. A. C. Walker, *Bell Telephone Laboratories, Inc., New York, N. Y.*
3. **The Place of Statistics in Textile Research.** Mr. J. P. Elting, *Kendall Mills, Paw Creek, N. C.*
4. **The Physical Basis of Color Measurement.** Professor A. C. Hardy, *Massachusetts Institute of Technology.*

Saturday Afternoon at 2:00 o'clock at Chapel Hill

Phillips Hall, Room 206

21. A Simple Demonstration in Sound. J. C. Mouzon, *Duke University.*—The existence of harmonics in a tuning fork and the suppression of certain harmonics by a closed resonating air column may be beautifully demonstrated through the medium of an oscilloscope. A microphone is coupled to the oscilloscope and a vibrating tuning fork mounted on a resonating box (one end closed) is presented to the microphone. The pattern on the oscilloscope screen usually indicates a complex wave form. When, however, the open end of the resonating box is presented to the microphone a very nice sine wave is seen on the screen of the oscilloscope. It is evident then that the majority of the distortion of the wave is due to the even harmonics of the fork. The second harmonic is usually audible if the fork is not struck with extreme care. It, of course, cannot exist in the closed resonating box.

22. A Quantitative Study of the Doppler Effect in Sound Waves, Newland F. Smith, *The Citadel.*—A whistle, built into the end of a long tube, is rotated by a motor at constant speed. The sound of the whistle is impressed upon a microphone in the plane of rotation of the whistle, and the resulting current is amplified. A photographic record of the amplified current is obtained by means of an oscillograph. From this photograph, the frequency of the note is determined when the source is approaching and receding from the microphone with a known velocity. Theoretical and observed values of the changes in frequency are compared. The sound may be recorded on a phonograph disk and a permanent record made.

23. New Values of the Change of Resiliency with the Velocity of Impact, John B. Derieux, *North Carolina State College of the University of North Carolina.*—Golf balls were selected as suitable bodies with which to make the study. The change in velocity was obtained by dropping the balls from heights varying from three to sixty feet onto a large stone slab, and the corresponding resiliency was determined from the height of rebound. The velocities could be computed from $V = \sqrt{2gh}$, however, because of the resistance of the air. The resistance at different velocities had first to be determined, and this was done by placing the balls in a wind tunnel and measuring the drag of the air at different speeds. The equation of resistance against velocity was determined from these data, and incorporating it in an equation between height and velocity an infinite series was obtained by which the correct velocities were computed. The values of the resiliency showed a decided decrease with increase of velocity of impact. This being the case, it proposed that the standard values of resiliency should be those with zero velocity. This value can be determined from the graph of the finite values against velocity extended to zero velocity, or from the equation of resiliency against velocity when zero is substituted as a velocity.

24. The Distribution in a Horizontal Plane of Light from a Point Source, W. L. Brenner, *The Citadel.*—A Weston photronic cell with attached galvanometer is placed on a horizontal surface. A concentrated filament lamp, free to move vertically, is varied in height. Readings of the galvanometer are taken for each position of the lamp, and a curve plotted showing the relation between lamp height and the horizontal distance from the cell to the point immediately below the lamp. From this curve, the height of the lamp giving maximum illumination on the cell is determined. This point can also be determined from theoretical considerations involving the inverse square law and Lambert's law. The above procedure correlates in the student's mind the laws of illumination and the calculus treatment of maxima in a single experiment. The entire apparatus may be housed in a black box and, since the galvanometer may be placed outside, the experiment may be performed in a lighted room.

25. Diffraction Patterns by Polarized Light. A. W. Dicus, *Tennessee Polytechnic Institute.*—To obtain these patterns, a diffraction tube, about thirty feet in length and

nine inches in diameter, was used. One end was fitted with a spring clamp to receive a plate holder and on the other end of the tube was fastened a metal plate containing four or five small holes to be used as apertures. Near the center of the tube was an opening to permit the insertion of objects of which patterns were to be made. The box shaped opening was covered with a light-tight lid. The source of light was a carbon arc. The light was filtered through blue glass and then focused on the Nicol prism of a polariscope tube. To the opposite end of this tube was fastened a Polaroid disk to be used as an analyzer. This beam of plane polarized light was then focused on a small aperture in the end of the diffraction tube. The plane of polarization was horizontal. Patterns were taken with a number of objects and in each case the diffraction was equally evident in both horizontal and vertical directions. Following is a list of patterns: 1. Screen-wire as an object, monochromatic nonpolarized light. 2. Same object as No. 1 but monochromatic polarized light was used. 3. Razor blades as object, monochromatic nonpolarized light. 4. Razor blades as object, monochromatic polarized light. 5. Razor blades as object, monochromatic polarized light. The Nicol prism was removed and the Polaroid disk used as a polarizer. 6. Razor blades as an object, monochromatic polarized light. Both the Nicol prism and Polaroid disk removed and the disk was placed inside the diffraction tube, thus polarizing the light after passing through the aperture.

26. Observation of Spectra—An Experiment for the Elementary Laboratory. PAUL E. SHEARIN, *University of North Carolina.*—We have recently introduced into our elementary laboratory an experiment on the observation of spectra. Four different types of spectroscopes are used, each with a different kind of source. Wave-lengths of line spectra are measured. Selective absorption of certain liquids is used as a simple method of chemical analysis.

27. An Elementary Laboratory Experiment Dealing with the Relationship $I = Q/t$. J. H. HOWEY, *Georgia School of Technology.*—The calibration of a condenser by the tuning fork method has long been a standard experiment in physics, but it is not commonly included in elementary laboratory courses. By considering the experiment as a calibration of a galvanometer using a known capacity, the experiment has been adapted for use in an elementary laboratory course. As such, it possesses a number of desirable features. It can be scheduled earlier in the course than most other experiments in electricity because the necessary theoretical background is covered early in the course, if the usual logical order is followed in class work. The required apparatus is inexpensive except for the galvanometer which is already available in most laboratories. Finally the principles involved are fundamental relationships in electricity with which every student should be made thoroughly familiar. The advent of radio and other branches of electronics has made it more imperative than ever that the principles involved in this experiment be emphasized.

28. Laboratory Demonstration Experiments in Modern Physics. D. S. ELLIOTT, *Tulane University.*—This paper outlines the methods developed at this university for giving the junior student definite perceptual knowledge of the principal phenomena of modern physics, as addenda to the traditional half-year course in electricity and magnetism.

29. The First Courses in Physics in American Colleges. CHARLES W. EDWARDS, *Duke University.*—A statistical analysis is made of current practices in American colleges with a brief discussion of the relation of the Preliminary Physics, the General Physics, and the Intermediate Physics courses to the type of student body served in different sections of the country, and to the different objectives of the students in each type of institution. An exhibit is made of the great variety of procedures which are being employed by teachers of physics to reach a common goal. (Lantern slides.)

30. A Description of the Physical and Astronomical Equipment at the University of Mississippi Prior to 1860. W. L. KENNON, *University of Mississippi.*—A description, supplemented by slides, photographs, and exhibits, of a remarkable collection of physical and astronomical equipment acquired by the University of Mississippi between 1850 and 1860. Apparatus purchased in 1851 from John Millington, first professor of natural philosophy in the university, brought to Mississippi by Millington from the Royal Institution (London); among other pieces of historic interest it includes a unit from the famous battery which furnished current for Davy, and for Faraday, for their classic experiments. An elaborate collection of the highest grade research equipment mostly by Lerébours et Secrétan (Paris), which comprised a complete replica of the apparatus described and illustrated in *Jamin's Cours de Physique.* A collection of 80 oil paintings by Atélier Clichy (Paris), large four prism spectroscope by Steinheil, complete set of Koenig's original manometric flame apparatus, and replicas of practically all classic apparatus of the period. The oil paintings appear to have been the originals from which were made the beautiful color plates in *Les Phénoménes de la Physique par Amédée Guillemin* (Paris), 1869. As a part of the astronomical equipment might be mentioned the undelivered nineteen inch Dearborn Objective ground by Alvin Clark to the order of the University.

31. Quizzes and Examinations in Physics. NEWTON S. HEROD, *Georgia School of Technology.*—Quizzes and examinations are discussed as an integral part of a teaching program. This makes it necessary to discuss the adaptation of questions to the group dealt with, the method of rating various types of questions, and the treatment that follows the return of papers after they are graded.

32. Recording Machines as a Means of Teaching and Advertising Physics. L. E. MCALLISTER, *Berry College.*—In order that physics may have its rightful place in an educational institution it must touch in a practical way the lives of as many individuals as possible. At Berry College that is done in many ways. Among them is the use of recording machines for making phonograph records. Advanced students in physics learn the theory and operation of the machines by study and by assisting in their operation. This includes a knowledge of sound itself, the

microphone and amplifiers as well as the actual recording. Records are made for individuals in the form of personal greetings, songs, poems, etc., to send home at Christmas and Easter time. The music and public speaking departments make records for teaching purposes. Choirs and other ensembles make records of their productions before presentation to note mistakes that should be corrected. Individuals, singing or speaking, have a chance to hear themselves as others hear them. Their teachers say the students learn more from one record than from a dozen lessons. Actually it benefits other departments but at the same time it gives students more respect for and interest in the subject matter of physics.

33. Present Tendencies and Status of Physics in the High Schools of the South. C. R. FOUNTAIN, *George Peabody College for Teachers.*—Preliminary reports from various southern states indicate that physics is not being given in as large a percentage of the high schools, nor is it being elected by as many students where given as it was twenty years ago. Among the many suggestions offered as possible causes for this changing attitude may be mentioned: (1) General belief by students, parents and school executives that physics is useful only for students planning for some field of engineering. (2) That physics taught in the high schools is being ignored by colleges and universities. (3) Budget cutting is most effective when applied to physics equipment. (4) Physicists do not advertise their accomplishments. (5) Courses in physics have been too hard and too formal. (6) Laboratory apparatus has been too complicated and unfamiliar. To offset this tendency we should: (1) Show that physics is the easiest of all the subjects with which to learn to think. In no other subject is it so easy to see the effect of changing just one factor or to check one's reasoning. (2) Show that we use physics in every move we make, in athletic games and in our daily work. (3) Show that physics helps us judge most of the materials and the machines we buy.

SATURDAY AFTERNOON AT 2:00 O'CLOCK AT CHAPEL HILL

Venable Hall, Room 206

34. The Effect of an Electric Field on the Diffraction Pattern of Liquids. A. A. BLESS, *University of Florida.*—The negative results obtained by F. C. Todd (Phys. Rev. **44**, 787 (1933)) on the effects of an electric field on the x-ray diffraction pattern of nitrobenzene are not altogether conclusive for the following reasons: 1. Temperature changes were prevented by using the liquid in the form of a stream running through a tube. The disturbances thus introduced may have been counteracting the effects of the field. 2. The ionization chamber method employed is not suitable if the action of the field is such as to produce a pseudo-crystalline state in the liquid. To overcome these objections experiments were made on the effects of an electric field on the diffraction pattern using the photographic method with the fluid in a container which could be kept at any desired temperature. No changes were observed in the diffraction pattern produced in nitrobenzene and in methyl alcohol by Mo K_α radiation with fields up to 10 kv/cm, applied parallel to the direction of the x-ray beam as well as perpendicular to it.

35. The Physical Constants of the Ossicles of the Human Ear. OTTO STUHLMAN, JR., *University of North Carolina.*—Data represent mean values from nine complete sets of human ossicles. Experimental data obtained from 26X models made from the average data indicated.

Malleus: mass 22.9 mg. Over-all length 8.5 to 9.00 mm, from end of lateral process to end of manubrium 5.5 to 6.00 mm, angle between head and manubrium 145°, angle between head and lateral process 70°. Center of gravity in neck at corda tympani. Tensor tympani attached just below this point, lever arm to center of gravity 1.0 mm, manubrium lever arm 6.5 mm. Angle between axes of head and manubrium 145°, lateral process and manubrium 70°.

Incus: mass 27.4 mg. Over-all height along axis of long crus 7 0 mm, at right angles from short crus to facet 5.0 mm, height of facet 3.5 mm. Axis of short crus set at 35° to axis of long crus. Angle between long and short crus 85° to 90°. Center of gravity 5.0 mm above lenticular process. Long crus lever arm 5.0 mm from center of lenticular process to center of articulation facet.

Stapes: mass 3.5 mg. Over-all vertical height to foot plate 4.00 mm. Foot plate, length 3.2 mm, width at middle 1.4 mm. Area 3.2 sq. mm. Posterior crus compression member, anterior crus tension member for hinged vibration around posterior end of foot plate. Resultant tension supplied by stapedius muscle. Superior arch Gothic, inferior arch parabolic. Gothic arch tension, parabolic arch compression for hinged vibration around inferior edge of foot plate. Cross sections through crura U-shaped.

Fenestra ovalis to fenestra rotunda areas ratio 3 to 2. Conical depression at center of membrana tympani subtends 135°.

36. The Striking Potential of the High Frequency Discharge in Hydrogen as Conditioned by Frequency. SHERWOOD GITHENS, JR., *University of North Carolina and Wake Forest College.*—Having developed a high frequency oscillator (described in Feb. 1937 R. S. I.) which inherently measures the potential it generates, the striking potential of hydrogen was observed using polished brass electrodes, 3.7 cm in diameter, 1.4 cm apart, in the center of a spherical 5-liter Pyrex flask, over the range of frequency from 5 to

10.5 megacycles, with pressures varying from 0.01 to 130 mm Hg. The curves which will be shown reveal, among other things, the existence of a "critical spark length" for the h.f. discharge, analogous to that observed using spherical brass electrodes in air and an induction coil. At pressures below the critical pressure, which depends upon both the electrode separation and the frequency of the applied e.m.f., the glow emerges from between the electrodes, being maintained, and apparently having been struck, over a distance greater than the electrode separation. A considerably higher potential is required to strike the discharge in this pressure range. The data indicate that the h.f. "critical spark length" decreases progressively with increase in frequency in the ranges examined.

37. Improved Scale-of-Eight Recording Circuits. FOREST E. BRAMMER AND ARTHUR E. RUARK, *University of North Carolina.*—Shepherd and Haxby (R. S. I. Nov. 1936) have described a scale-of-eight counter using tubes between the stages to prevent blowing out the arc by negative impulses on the grids. We have constructed and tested two simplified circuits in which these coupling tubes are eliminated by employing only a fraction of the pulse available at the output of one stage to excite the next. In one of these circuits grid batteries are also eliminated. Uniform pulses are fed to the circuits by a choked multivibrator of the type described by Evans (R. S. I. Dec. 1936).

38. Fluctuations in the Counts of Geiger Counters. RAYMOND L. DRISCOLL AND ARTHUR E. RUARK, *University of North Carolina.*—Before a previous meeting of the Society one of us (R. L. D.) described an apparatus for automatically recording all counts occurring in a Geiger counter and also all intervals between adjoining counts which are longer than a chosen time T. Improvements in the apparatus and results obtained with it will be described.

39. Time Delay Circuits for Operating Wilson Cloud Chambers. CREIGHTON C. JONES, *University of North Carolina.*—Circuits have been developed in which grid glow tubes with time delay inputs perform all the switching operations necessary to operate a Wilson cloud chamber and its accessory mechanisms. The cycle of operations can be initiated either at regular intervals (by a motor and reduction gear) or by coincidences in Geiger counters placed above and below the chamber. Change over from one mode of operation to the other is very simple, being effected by a double pole double throw switch.

40. Theory of the Three Regions of the Ionosphere. E. O. HULBURT, *Naval Research Laboratory.*—The ionization of the upper atmosphere in thermodynamic equilibrium with solar radiation is calculated by the theory of Saha as modified by Pannekoek to refer to the atmosphere of the earth. Assuming that oxygen and nitrogen are atomic for the sun overhead, maximum electron densities of 4×10^5 and 1.3×10^5 are found at 230 and 290 km, respectively, in agreement with the observed F_1 and F_2 regions, F_1 being due to O and F_2 to N. Assuming that for large solar zenith angles and at night oxygen and nitrogen revert to the molecular state the calculated changes in F_1 and F_2 agree with those observed. A third maximum due to He of 900 electrons cm^{-3} is found at 60 km, which does not agree well with the observed E region. In this respect the theory is erroneous or incomplete.

41. Cosmic-Ray Shower Production in Large Thicknesses of Lead and Iron. KARL Z. MORGAN, *Lenoire Rhyne College,* AND W. M. NIELSEN, *Duke University.*—A study has been made of twofold coincidences associated with various thicknesses (up to about 600 g/cm^2) of lead and iron above the counters. The usual maxima in the curves are observed at thicknesses of approximately 20 g/cm^2 for lead and iron, respectively. If the right-hand side of the Rossi transition curve be interpreted as indicating the absorption of the shower producing radiation the data may be interpreted as indicating a soft and hard component, the absorption coefficients of which are for lead, 0.030 cm^2/g Pb and 0.0006 cm^2/g Pb, respectively. These coefficients are very nearly the same as those observed by Auger, LePrince-Ringuet and Ehrenfest (J. de phys. 7, 58 (1936)) for the absorption of cosmic rays with three counters in a vertical line. In the case of iron the corresponding absorption coefficients are 0.007 cm^2/g Fe and 0.00044 cm^2/g Fe. Coincidences due to the hard component obtained by extrapolating the estimated soft component into the region of larger thicknesses show a maximum for lead at a thickness of about 225 cm^2/g. For iron there is an indication of a maximum at about 550 cm^2/g.

42. Cosmic-Ray Shower Production in Lead of Various Thicknesses. WALTER M. NIELSEN, *Duke University,* AND KARL Z. MORGAN, *Lenoire Rhyne College.*—Measurements have been made of showers consisting of a minimum of two, three, and four particles produced in various thicknesses of lead up to 240 g/cm^2. The ratios between doubles, triples and quadruples at the larger thicknesses (at about 240 g/cm^2) were not significantly different from the corresponding ratios at smaller thicknesses near the maxima of the Rossi transition curves. The results also indicate that the thickness corresponding to the first maximum in the transition curve occurs at a larger thickness for quadruples than for doubles.

43. The Influence of Temperature on the Reaction of Hydrogen Atoms with the Wall. GERTRUD KORNFELD. (Introduced by Frances G. Wick, *Vassar College.*)—Hydrogen and chlorine combine with each other at 220°C by a chain reaction very similar to the chain mechanism underlying the photochemical reaction at room temperature. In both reactions the atoms of hydrogen and chlorine are the chain carriers, but at 220°C the chains are much more frequently stopped by collisions of the atoms with the wall. The absolute value of the rate of reaction gives the number of these collisions and by calculating approximately the number of collisions occurring with the wall it can be shown that at 220°C nearly every collision of a hydrogen atom with the wall is effective. The reaction at

room temperature yields quite different results and this difference is further discussed.

44. An Axial Magnetic Suspension. F. T. HOLMES, *University of Virginia.*—A vertical magnetic needle suspended by the coaxial field of a solenoid has theoretically the properties of infinitesimal friction and restoring torque. Such a needle can be made macroscopically steady by using a variable magnetic field and appropriate damping devices. In the present arrangement two suspending solenoids are used. A steady current flows through one and a variable current through the other. The variation is produced by the partial interruption of a beam of light striking a photo-cell by a vane mounted on the needle. The same photo-cell controls a third coaxial solenoid which supplies, by virtue of a stage of transformer-coupled amplification, damping forces opposing and roughly proportional to the vertical velocity of the needle. A copper disk just below the lower end of the needle provides sufficient transverse damping in some cases. Torsional sensitivity obviously depends on symmetry of all mechanical and magnetic items.

45. An Inverted Ultracentrifuge. J. W. BEAMS AND F. W. LINKE, *University of Virginia.*—An air-driven "vacuum" type of ultracentrifuge is described in which the large rotor or "centrifuge" is mounted upon a flexible shaft (rod or tube) extending upward from the turbine rather than downward as in the original design.[1] The turbine is situated below the vacuum tight chamber which surrounds the centrifuge. The small flexible shaft connecting the turbine and the centrifuge lies in their vertical axis of rotation and passes through an air-tight oil gland which seals the vacuum chamber. The rotating parts are supported on an air cushion below the turbine and are driven by air jets which impinge upon the flutings of the turbine. The motion of the centrifuge is very stable and smooth and the maximum rotational speed is set only by the strength of the centrifuge.

[1] Beams and Pickels, R. S. I. 6, 299 (1935).

46. A Steam-Driven Ultracentrifuge. L. G. HOXTON AND J. W. BEAMS, *University of Virginia.*—An ultracentrifuge similar in design to one previously described[1] but driven by steam instead of air has been constructed. The rotating parts consist of (1) a steam-driven, air or steam supported turbine, (2) a large rotor (centrifuge) which spins in a vacuum tight chamber, and (3) a small flexible shaft that extends vertically downward from the turbine above the chamber through a vacuum tight oil gland to the centrifuge which it drives and supports. The maximum rotational speed is limited by the bursting strength of the centrifuge. The centrifuge and the vacuum tight chamber, which surrounds it, are maintained at a constant temperature by circulating water around the chamber. The steam is generated electrically.

[1] Beams and Pickels, R. S. I. 6, 299 (1935).

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

The papers in the supplementary program may be called for only at the session indicated.

47. The Sensitiveness of Paraffin Crystal Formation to the Physical and Chemical Conditions Under Which They Crystallize.* CHARLES M. HECK, *North Carolina State College of Agriculture and Engineering.*—The progressive modifications of shape and internal structure of paraffin crystals have been photographed and are found to be related to the physical and chemical conditions under which they are formed. The normal pinacoidal diamond-shaped tabular crystals are found to have certain points of their exterior outline more sensitive to changes in these conditions than others. A number of series of progressive variations are shown and classified with respect to the type of physical or chemical variation assumed to be causing the change. Variations in the form of parallel striations across the crystal face are also related to the changes in these conditions during formation.

* To be called for after Paper No. 20.